Industrial Technologies Program

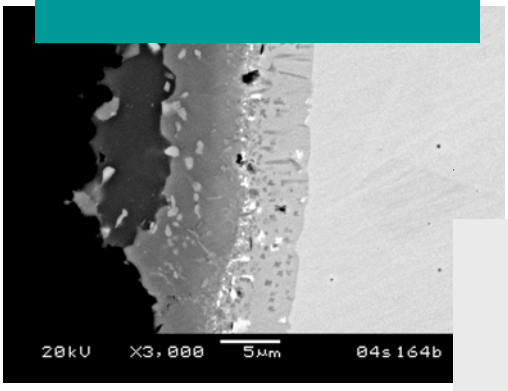
Advanced Composite Coatings for Industries of the Future

Application of Ceramic Coatings Derived from Preceramic Precursor Polymers Will Provide an Economical Solution to High-Temperature Corrosion

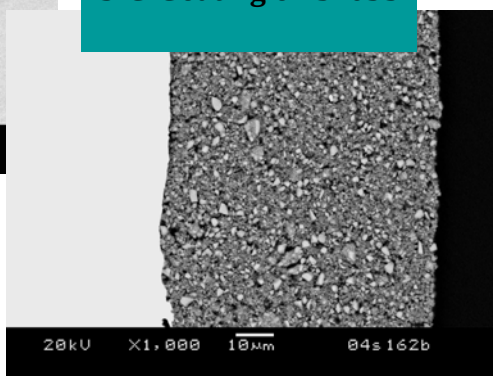
Corrosion is a challenge that crosscuts all industries and is estimated to cost U.S. industry $300 billion per year. Although corrosion-resistant coatings are currently in use, enhanced performance requires improved coating materials and coating methods. Cost-effective coatings can save money by increasing the lifetime of industrial components and by allowing for substitution of expensive materials with less-expensive substrate and coating combinations. This project will focus on two low-cost methods for obtaining advanced composite coatings with improved corrosion resistance for industrial use: pyrolysis of preceramic precursors and in situ displacement reaction synthesis.

Corrosion-resistant coatings can reduce manufacturing costs by extending component lifetimes and by allowing substitution of more economical substrates. In addition, corrosion-resistant coatings can improve process efficiencies and hence, lead to energy savings and reduction of emissions. Furthermore, low-temperature routes to ceramic coatings can result in additional energy savings, cost savings, and emissions reduction. Composite coatings containing several functional phases can also provide an effective means for improving performance because compositions and microstructures can be tailored to address critical problems.

Aluminide Coating on 316SS



SiC Coating on 316SS



Benefits for Our Industry and Our Nation

- *Coatings are designed to allow use of low-cost steels rather than superalloys*
- *Simplified coating application methods will reduce maintenance costs*
- *Enhanced corrosion resistance will lead to an estimated 5% increase in efficiency*

Applications in Our Nation's Industry

IOF industries include:

- Chemicals - hydrogen production, reformers
- Petroleum - reformers
- Steel - new aluminizing method

Project Description

The goal of this project is to develop low-cost ceramic coatings for prevention of high-temperature corrosion of metals and ceramics in industries such as chemical processing and industrial power generation. These coatings are targeted at providing high-temperature (700-1000°C) protection from corrosion due to oxidation, carburization, coking, and metal dusting.

Barriers

- Lack of low-cost coating to prevent carburizing of steels in steam-reformer environments
- Lack of low-cost method to apply ceramic coatings to steel

Pathways

To mitigate high temperature corrosion, two novel methods will be used to synthesize and fabricate ceramic-composite coatings suitable for large-scale field application: pyrolysis of preceramic precursors and in situ displacement reaction synthesis. Once these methods are developed, an industrial partner will help to ensure the coatings are tested and evaluated properly. Additionally, a coating method will need to be developed and tested to allow for an easy, cost-effective way to apply the ceramic coating on the steel.

Milestones

Results to Date

- Three new coatings have been developed that survive 10 cycles to 800°C on 316 stainless steel (SS) and 100 hours at 800°C
- A patent has been applied for a new method of producing aluminized coating on steels
- A novel 316SS-flake coating has been developed to grade high-CTE metals to ceramic outer corrosion resistant coatings
- Use of organic solvents and painting, dipping or spraying coating techniques have been developed

Future Milestones

- Work with Air Products and Solar Turbines to ensure that coatings are tested and evaluated properly
- Continue to improve aluminide coating layer by controlling aluminum concentration gradient during processing
- Further develop method to grade the CTE of 316SS to allow dense ceramic conversion coatings
- Compare *in situ* reacted coatings with inert particle-filled coatings for cost and performance
- Prepare agreements with commercial painting companies for testing

Commercialization

The development of a liquid coating method based on a low-viscosity slurry or paint is the desired end product of this project. Working with the painting industry, this technology will be further developed such that an inexpensive coating solution for carburization and coking in the chemical process industry can be realized. Project partner Air Products Research will be provided with enough material so that an adequate field test can be performed. A patent for the process (method and material) will be filed to ensure intellectual property rights.

Project Partners

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Air Products Research
Allentown, PA

Solar Turbines
San Diego, CA

SRI, Inc.
Menlo Park, CA

The University of Washington
Seattle, WA

The University of Central Florida
Orlando, FL

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. Department of Energy
Energy Efficiency and Renewable Energy

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